Belief Distortion Near 52W High and Low: Evidence from Equity Options Market

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Abstract

We examine investors' behavioral biases and preferences in the options market near 52-Week high and low (52W-H/L). We document that as the stock price approaches 52W high (low), the skewness of RND and out-of-the-money (OTM) call volume decreases (increases), while OTM put volume increases (decreases). After crossing the 52W high (low), the skewness of RND and OTM call volume increases (decreases), while OTM put volume decreases (increases). The effects are economically large and significant. Our findings provide evidence consistent with anchoring theory of belief distortion near 52W-H/L. There is no evidence of preference distortion, contrary to what prospect theory predicts.

Keywords: Anchoring Theory, Prospect Theory, Reference Point, Behavioral Finance, Attention, Options Market, Emerging Market

JEL: G12, G13, G14, G40

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1. Introduction

The 52-week high and low (52W-H/L) prices represent salient price points and visible anchors of interest to investors. Investors are known to exhibit various behavioral biases or preferences around 52W-H/L (Huddart, Lang and Yetman, 2009; Driessen, Lin and Van Hemert, 2013). Previous research has shown that nearness to or breaching the 52W-H/L prices influences investors' trading behavior in the stock market (Grinblatt and Keloharju, 2001), which has implications for the exercise of options, trading volume, and asset prices (Heath, Huddart and Lang, 1999; Poteshman and Serbin, 2003; Huddart et al., 2009; George and Hwang, 2004).[1] The extant literature on the behavior of financial markets near 52W-H/L focuses primarily on stock markets, with very few studies in the options market.[2] The options market is forward-looking and contains useful information about the future return of the underlying security (Xing, Zhang and Zhao, 2010; An, Ang, Bali and Cakici, 2014; Zhou, 2022). It thus reflects both the risk preferences and future expectations of the investors and thus provides an ideal avenue to examine the investors' behavior near 52W-H/L. The purpose of this study is to investigate the investors' risk preferences and expectations (beliefs) near 52W-H/L using options implied risk-neutral-density (RND) and volume.

The options market provides leverage and lottery-like payoffs that can attract a lot of speculators, and yet there are very few studies that examine investors' behavioral biases or preferences in the options market in general and near 52W-H/L in particular (Muravyev and Ni, 2020). However, it is important to do so for various reasons. First, options trading has grown considerably and now accounts for a sizable portion of the global financial market.[3] Second, previous studies have documented that options trading improves spot markets' informational efficiency by facilitating the information flows (Kumar, Sarin and

[1]Because of psychological reasons, 52W high has also been used as reference points for other purposes such as pricing of mergers and acquisition deals (Baker, Pan and Wurgler, 2012).

[2]Driessen et al. (2013) is an exception, but the paper is limited to the examination of implied volatility and stock return moments around 52W-H/L.

[3]In both developed and developing markets, options volume recently reached a historic high. After 2020, the Indian equity options market also witnessed a huge increase in trading volume due to margin related changes introduced by market regulator (FIA, 2021). Similarly, in the United States in August 2020, the equity options volume exceeded stock volume by 20% (Zuckerman and Banerji, 2020).

Shastri, 1998; Jong, Koedijk and Schnitzlein, 2006; Chern, Tandon, Yu and Webb, 2008). In this regard, any evidence of behavioral biases or preferences in the options market would lower the quality of information flowing from the options market to the spot market, with serious implications for the market efficiency. Third, because options are used for hedging, any belief or preference distortion would reduce the effectiveness of options as a hedging tool.

We examine the behavior of the second (volatility) and third (skewness) moments of RND and the relative volume of out-of-the-money (OTM) call and put options, as the stock price approaches and breaches the extreme prices (52W-H/L). We begin with developing predictions about the behavior of these variables around 52W-H/L using different theories established in the literature, namely, prospect theory (Kahneman and Tversky, 1979), anchoring theory (Tversky and Kahneman, 1974), and investor attention (Barber and Odean, 2008) to explain markets' behavior near 52W-H/L. These theories' predictions about the behavior of our variables of interest are somewhat contradictory and warrant empirical investigation.

If investors use 52W high and low as reference points to access profit or loss, the prospect theory (Kahneman and Tversky, 1979) predicts that investors will exhibit low (high) risk aversion when the stock price approaches 52W high (low), and high (low) risk aversion once the underlying stock price breaks through the 52W high (low). Risk aversion can affect the skewness of the RND as well as the volume of OTM options (both call and put). Low-risk aversion would cause an increase in the skewness and OTM call options volume and decrease in OTM put options volume, and vice-versa. If, on the other hand, 52W-H/L prices are used as anchors by the investors to form expectations, the anchoring theory (Tversky and Kahneman, 1974) predicts that when the stock price approaches the 52W high (low), investors' expectations about the further increase (decrease) in stock price will be downward (upward) biased. When the stock price breaks through the 52W high (low), investors' expectations about further increase (decrease) in stock price would be revised upward (downward). This distorted expectation can influence the skewness of the RND and the volume of OTM options. The downward (upward) expectation bias when the stock price approaches the 52W high (low) will manifest in the form of decrease (increase) in the skewness and OTM call volume and an increase (decrease) in OTM put volume. The expectation revision that occurs after the stock price breaks through the 52W high and low would reverse the trend observed in all of these variables during the approach period. Finally, the investors attention hypothesis (Barber and Odean, 2008) predicts high volatility following the breakthrough of 52W-H/L prices due to high investors' attention during that period. Because investors' attention increases only after the breakthrough, the attention hypothesis predict nothing for other variables during the approach period.

We use single stock options (SSO) trading data from the Indian market to test the theoretical predictions. The choice of the dataset is motivated by the fact that the Indian derivatives market is one of the world's most liquid markets with high retail investors participation (FIA, 2021). While retail participation in the US options market has been on the rise since the COVID 19 crisis (Schwartz, 2022), retail participation in India has always been high. Individual investors, for example, contributed between 23% and 28% of total notional turnover in the Indian SSO market in each year from 2016 to 2019 (NSE, 2022). The high retail participation makes it particularly suited to explore the behavioral biases and preferences. Our dataset consists of all SSO traded from January 2011 to December 2019 on the National Stock Exchange (NSE), which is India's largest exchange and accounts for close to 100% of the country's derivatives volume. As the liquidity of the SSO contracts varies considerably, we use high-frequency transaction data to generate time-matched SSO and single stock futures (SSF) prices. We use both the non-parametric method of Bakshi, Kapadia and Madan (2003) and parametric method (Xing et al., 2010) to estimate the volatility ($Volatility^{RND}$) and skewness ($Skew^{RND}$) of the RND. Our volume-based measures are calculated using the daily trading volumes of all SSO contracts. We investigate the behavior of our variables of interest in an event study setting around 52W-H/L.

Our key empirical results are as follows. First, as predicted by the investors attention hypothesis, we observe an economically significant increase in volatility of RND by two (six) percentage points, when the underlying share price breaches its 52W high (low). Second, consistent with the prediction of anchoring theory, we find that the skewness of RND and OTM call volume decreases (increases), and OTM put volume increases (decreases) as stock price approaches 52W high (low). This suggests that investors' expectation remains downward (upward) biased in the approaching phase of the 52W high (low). Third, in line with the predictions of anchoring theory, we find that the skewness of RND and OTM call volume increases (decreases), and OTM put volume decreases (increases) in the breakthrough period of the 52W high (low). The findings suggest that investors' revise their expectations upwardly (downwardly) when the stock price breaches the 52W high (low). Taken together, our empirical findings provides strong empirical evidence in favor of investors' belief or expectation distortion near 52W-H/L.

Our paper contributes to multiple strands of literature. First, we extend the literature pertaining to investors' behavior around 52W-H/L to a new asset class – SSO. In this context, we show that SSO investors, who are considered to be more sophisticated than equity investors, have behavioral belief distortion near 52W-H/L. Second, we add to the otherwise nascent literature on behavioral biases of options traders (see, Muravyev and Ni, 2020; Bernales, Verousis and Voukelatos, 2020). We contribute to this strand by demonstrating belief distortion amongst the SSO investors. Our findings supports the assertion of Lemmon and Ni (2014) that SSO investors are less sophisticated. Finally, we contribute to the growing literature on the use of (higher moments of) RND to investigate markets' expectations and risk preferences around specific stock market events (Bates, 1991, 2000; Birru and Figlewski, 2012). Our study uses higher moments of RND to examine the investors' expectations and risk preferences around particular stock-specific events, i.e., 52W-H/L. We, thus, extend this literature beyond exploring market-wide events to include stock-specific events. The remainder of the paper is organised as follows. The predictions of existing theories, applicable for the 52W-H/L, for the moments of RND and choices volume are discussed in section 2. Section 3 provides a brief overview of the institutional setting of Indian options market, describes data and how the variables are constructed. Section 4 describes our empirical techniques and in section 5 discusses our results. We discuss the findings from various robustness checks of our results in section 6, and conclude in section 7.

2. Literature Review and Theoretical Framework

Options price and volume contain useful information about investors' expectations and risk preferences. Options implied RND reflects both risk attitude and price expectations (Birru and Figlewski, 2012). It has been used extensively in the literature to explore markets' expectations about specific stock market events (Bates, 1991, 2000; Birru and Figlewski, 2012). Investors' risk attitude and price expectation around firm-specific events such as the formation of a new 52W-H/L have received less attention in the literature. While much of the work on 52W-H/L has concentrated on the stock market variables (George and Hwang, 2004; Huddart et al., 2009), limited work been done on options market variables (Driessen et al., 2013). However, previous studies have demonstrated that investors show behavioral risk preferences and beliefs near 52W-H/L. The options market, which reflects investors' belief and risk preferences both through the RND and volume, provides an ideal avenue to explore investors' behavior around 52W-H/L.

Past studies related to 52W-H/L in the spot market have used various theories such as prospect theory (Kahneman and Tversky, 1979), anchoring theory (Tversky and Kahneman, 1974), and investors attention hypothesis (Barber and Odean, 2008) to explain their empirical findings. In this section, we develop predicts about the behavior of RND moments and options volume near 52W-H/L using these theories.

2.1. Prospect Theory

According to the prospect theory (Kahneman and Tversky, 1979), decision-makers (investors) evaluate gains and losses with respect to a reference point and demonstrate loss aversion. The loss aversion is represented by an S-shaped value function that is concave (denoting risk-averse) in the gain domain and convex (denoting risk-seeking) in the loss domain with respect to the reference point.

In many financial applications, the purchased price of the security is considered as the reference point.[4] However, Heath et al. (1999) and Baker et al. (2012) have shown that 52W-H price also serves as a reference point. In this case, investors' risk aversion may increase drastically when the stock price crosses the reference point i.e., 52W-H. Therefore, if the majority of the investors show prospect theory kind of preference when the stock price is near 52W-H, the following consequences for options implied risk-neutral-density (RND) and volume should be expected.

First, a high-risk premium in the market will negatively skew the RND (Bakshi et al., 2003). As a result of the loss aversion induced in the gain domain, the prospect theory predicts that following the 52W-H breakthrough, the RND skewness will become highly negative. Prospect theory predicts that investors' risk aversion will remain low as we approach 52W-H, therefore RND will be less negatively skewed as we approach the breakthrough. Second, regarding the relative put and call options volume in the options market, prospect theory like preference will cause the following. Because of the low level of risk aversion while approaching the 52W-H, the OTM put volume would remain low and the OTM call volume would remain high. Similarly, high loss aversion after the breakthrough would increase the OTM put volume and decrease the OTM call volume.

There is no extant work that documents the 52W low (52W-L) as a reference point. But, assuming that this is the case, prospect theory would predict that investors would demonstrate loss aversion throughout the approach stage, but become less risk averse after the breakthrough. The consequence for the RND and volume would be the following. RND should become highly negatively skewed due to loss aversion when the stock price approaches 52W-L. Whereas, after it breaks through 52W-L, the investors' risk aversion would remain low causing the RND to remain less negatively skewed. As regards the volume of call and put options, the high level of loss aversion while a stock approaches the 52W-L would cause the OTM put volume to remain high and OTM call volume to remain low. Similarly, after the breakthrough, the OTM put volume would decline and OTM call volume would increase because of the low-risk aversion.

[4] Laboratory experiments have revealed that price levels other than the purchase price affect trading decisions, especially extreme past prices (Huddart et al., 2009).

2.2. Anchoring Theory

Tversky and Kahneman (1974) provides a psychological foundation behind anchoring, which indicates that individuals use irrelevant but salient anchors in belief formation. There is notable evidence that the 52W-H price is considered as a reference price by investors in the financial markets. [5] All previous research in this domain has used a common argument: equities near 52W-H are perceived as "expensive", leading to increased investors' skepticism that the price will increase further.[6] Hence, the anchoring theory suggests that if good news arrives near 52WH, investors will be hesitant to bid up the price above the anchor, even if the news warrants it. According to this theory, 52W-H acts as the resistance level. In the context of options markets, this implies that while the price approaches the 52W-H, the RND skewness would become highly negatively as the investors' belief remains negatively biased. Furthermore, the downward bias in belief can manifest in the form of increase in OTM put volume and decrease in OTM call volume.

Next, we turn to the implications of anchoring over the option-implied-RND and volume after the price crosses 52W-H. The anchoring theory predicts that when good news gets incorporated into the price and it breaches the 52W-H resulting in a new high price, the stock price would be expected to increase further. This would result in an upward revision of investors' beliefs about the future stock price. In the context of options market, this means that after the breakthrough, the RND's skewness would become less negative as investors' belief would be updated in the upward direction. Furthermore, the upward belief revision would manifest in the form of increase in the OTM call volume and decrease in OTM put volume.

As previously stated, no existing study documents 52W-L as an anchoring point. However, if we consider 52W-L to be a salient anchor, it will act as a support level for the stock price. Hence, if bad news arrives when the price approaches the 52W-L, investors

[5] For instance, Poteshman and Serbin (2003) finds that retail traders irrationally exercise stock options when prices exceed the past 52W-H. Similarly, George and Hwang (2004) argues that 52WH price acts as an anchor against which investors evaluate fresh information, and Baker et al. (2012) shows that 52WH price works as an anchor for valuing mergers and acquisitions deals.

[6] Birru (2015) provides evidence that 52WH act as a psychological barrier causing expectational bias and underreaction to the news.

will be reluctant to bid the price down below the support level, resulting in an upwardly biased belief distortion. In the context of options markets, this implies that leading to the 52W-L, the RND skewness will become less negative because the investors' belief will remain upwardly biased. The upward bias would manifest as higher (lower) volume of OTM call (put) options.

Eventually, when negative news gets incorporated into the price and the price breaks the support level, i.e., stock price falls below 52W-L, the anchoring theory predicts that investors will expect the price to fall even more, causing a downward revision of investors' beliefs about the future stock price. In the options markets context, this means that after the breakthrough, the RND skewness will become extremely negative as investors' beliefs will be revised downward. The downward shift in belief can manifest in the high (low) volume of OTM puts (call) options.[7]

2.3. Attention Hypothesis

Breaking out past 52W-H/L prices does not convey information about the fundamentals of the firms, but does draw investors' attention (Huddart et al., 2009). Barber and Odean (2008) finds that investors tend to trade more in stocks that grab their attention because they have limited capability to track the whole universe of stocks. Huddart et al. (2009) argues that when the stock price crosses the 52W-H/L it attracts investors' attention, which explains the strikingly high volume observed in the stock market after the breakthrough. The high volume following the breakthrough may increase stock volatility, which may be reflected in the volatility of the RND (Driessen et al., 2013). Hence, the attention hypothesis predicts an increase in the volatility of the stock following the breakthrough. The attention theory does not generate any prediction regarding the skewness of the RND and relative volume of call and put options. Furthermore, because attention increases only after the breakthrough, the attention hypothesis does not generate any prediction for the approach period.

[7]The predictions of anchoring theory are similar to technical traders' perception of 52W high (low) as resistance (support) level. Brock, Lakonishok and LeBaron (1992) provides evidence of technical traders viewing the 52W high (low) as a resistance (support) level, with breaking through this level indicating a buy (sell) signal.

The predictions generated by the three theories mentioned above are summarised in the table below.

Table 1: Theoretical predictions

Variables		*Prospect Theory*	*Anchoring Theory*	*Attention*
Panel A: Approaching/breaking through a 52W high				
$Volatility^{RND}$	Approaching	0	0	0
	Breakthrough	0	0	+
$Skew^{RND}$	Approaching	+	-	0
	Breakthrough	-	+	0
Volume OTM Call	Approaching	+	-	0
	Breakthrough	-	+	0
Volume OTM Put	Approaching	-	+	0
	Breakthrough	+	-	0
Panel B: Approaching/breaking through a 52W low				
$Volatility^{RND}$	Approaching	0	0	0
	Breakthrough	0	0	+
$Skewess^{RND}$	Approaching	-	+	0
	Breakthrough	+	-	0
Volume OTM Call	Approaching	-	-	0
	Breakthrough	+	+	0
Volume OTM Put	Approaching	+	+	0
	Breakthrough	-	-	0

3. Indian Derivatives Market, Data, and Variable Construction

3.1. Indian SSO Market

The Indian SSO market is very liquid and well-regulated. The National Stock Exchange (NSE) is the largest exchange where spot, single stock futures (SSF), and SSO trade simultaneously. It accounts for almost 99.99% of all derivatives contract traded in India. NSE is unique, both liquid SSF and SSO contracts trade on the same platform. The single stock (index) derivatives trading on NSE started in the year 2001 (2000) and by 2021 it has become the world's largest derivatives market by volume. NSE registered a growth rate of 48.7% in trading volume to reach 8.85 trillion futures and options contracts during the year 2021, nearly twice the volume in CME Group (4.82 trillion) and four times the volume in the Korean Exchange (2.18 trillion) (FIA, 2021). According to the World Federation of Exchanges 2019 report, NSE is ranked sixth and second in the world by SSO and SSF volume (WFE, 2019). Recent studies have found the Indian equity options market is micro efficient and has low mispricing (Jain, Varma and Agarwalla, 2019). After January 2011, all the SSO traded on NSE are European in nature.

In India, unlike the US, not all listed stocks act as underlying for SSO; only a subset of large-cap stocks belonging to a diverse set of industries have options traded on it. The Security and Exchange Board of India (SEBI), Indian stock market regulator, specifies the eligibility criteria for introduction and removal of securities from the derivatives segment. The eligibility criteria considers average daily market capitalization, traded values, deliverable value, and quarter sigma.[8] Sometimes large IPOs are included in the derivatives segment right from the date of listing. Previous research have documented the existence of a large expiry day effect and market manipulation in the illiquid SSO/SSF in the Indian market (Agarwalla and Pandey, 2013; Jain et al., 2019).

In this study, we consider all the near-month SSO contracts (contracts expiring the last thusday of every month) traded on the NSE from January 2011 to December 2019. The fact that the SSO volume increased significantly after January 2011, when the NSE switched from American to European options (Jain et al., 2019) prompted us to choose that date as the start date. We ended our sample period in December 2019 to avoid the COVID-induced market meltdown. The SSO and SSF price data comes from the NSE trade book with matching time stamped quotes, and volume data comes from the NSE BHAV files. Following Jain et al. (2019) and Agarwalla, Saurav and Varma (2022), we applied various filters to the options price data. First, we removed options contracts that traded for less than (any) five minutes on a day. Second, we eliminated SSO contracts whose price was outside the Black models' arbitrage bound. This left us with more than 3.9 million contract-day observations.

[8]For more details please see https://www1.nseindia.com/products/content/derivatives/equities/selection_criteria.htm.

3.2. Independent Variable construction

3.2.1. Risk-Neutral Density Moments

Using the model-free approach of Bakshi et al. (2003) and OTM options prices, we estimate the second and third moments of options implied-RND for each stock-day. For estimation of RND of stock (i) on date t, we use the prices of all OTM options and the SSF price $(SSF_{i,t})$ for contracts expiring at a date $t+\tau$, and continuous compounding return on a risk free investment (r) made at time t and liquidated at time $t+\tau$. The options price data and the risk-free rate are taken from the NSE trade book and Bloomberg respectively. Dividend yield adjustment is not required because we use SSF price instead of the stock price in all our estimations, the existence of a liquid SSF market allows us to do that.

Bakshi et al. (2003) demonstrate that the annualized variance (Var^{RND}) and skewness $(Skew^{RND})$ of the RND of a stock's (i) from present time (t) to future time (τ) are given by:

$$Var^{RND}_{i,t,\tau} = \frac{e^{r\tau}V_{i,t,\tau} - \mu^2_{i,t,\tau}}{\tau} \tag{1}$$

$$Skew^{RND}_{i,t,\tau} = \frac{e^{r\tau}W_{i,t,\tau} - 3\mu_{i,t,\tau}e^{r\tau}V_{i,t,\tau} + 2\mu^3_{i,t,\tau}}{[e^{r\tau}V_{i,t,\tau} - \mu^2_{i,t,\tau}]^{3/2}} \tag{2}$$

Where,

$$\mu_{i,t,\tau} \equiv e^{r\tau} - 1 - \frac{e^{r\tau}}{2}V_{i,t,\tau} - \frac{e^{r\tau}}{6}W_{i,t,\tau} - \frac{e^{r\tau}}{24}X_{i,t,\tau} \tag{3}$$

,

$$V_{i,t,\tau} \equiv \int_{SSF_{i,t}}^{\infty} \frac{2(1 - ln\frac{K}{SSF_{i,t}})}{K^2} C_{i,t,\tau,K}dK + \int_{0}^{SSF_{i,t}} \frac{2(1 + ln\frac{SSF_{i,t}}{K})}{K^2} P_{i,t,\tau,K}dK \tag{4}$$

,

$$W_{i,t,\tau} \equiv \int_{SSF_{i,t}}^{\infty} \frac{6\ ln\frac{K}{SSF_{i,t}} - 3(ln\frac{K}{SSF_{i,t}})^2}{K^2} C_{i,t,\tau,K} dK - \int_{0}^{SSF_{i,t}} \frac{6\ ln\frac{SSF_{i,t}}{K} + 3(ln\frac{SSF_{i,t}}{K})^2}{K^2} P_{i,t,\tau,K} dK \tag{5}$$

,

and

$$X_{i,t,\tau} \equiv \int_{SSF_{i,t}}^{\infty} \frac{12(ln\frac{K}{SSF_{i,t}})^2 - 4(ln\frac{K}{SSF_{i,t}})^3}{K^2} C_{i,t,\tau,K} dK + \int_{0}^{SSF_{i,t}} \frac{12(ln\frac{SSF_{i,t}}{K})^2 + 4(ln\frac{SSF_{i,t}}{K})^3}{K^2} P_{i,t,\tau,K} dK \tag{6}$$

In the above, $V_{i,t,\tau}$, $W_{i,t,\tau}$, and $X_{i,t,\tau}$ represent fair value of payoffs of volatility contract, cubic contract, and quartic contract. $C_{i,t,\tau,K}$ ($P_{i,t,\tau,K}$) is the price of OTM call (put) of stock i on date t having time to maturity τ and strike price K. $SSF_{i,t}$ is price of futures contract of stock i at time t.

To compute the aforementioned integrals that appear in $V_{i,t,\tau}$, $W_{i,t,\tau}$, and $X_{i,t,\tau}$, a continuous of OTM options prices would be needed. However, options trade with discrete and limited strike prices. Following Dennis and Mayhew (2002); Duan and Wei (2009); Conrad, Dittmar and Ghysels (2013); Bali and Murray (2013), we use a trapezoidal method to estimate V, W, and X from observed options price which have discrete strikes. We applied the following filters to the options data to make sure that our data does not violate any arbitrage conditions. First, we remove all the SSO contract-day pair for which the call (put) option price C_i (P_i) does not satisfy $C_i > max[0, SSF - K]$ ($P_i > max[0, K - SSF]$). Second, we remove all the in-the-money (ITM) options contract (i.e., call options with $SSF_i > K$ and put options $SSF_i < K$) from the data. Third, we sort all the remaining calls (puts) in ascending (descending) order of strike price. Options price should decrease as we move further out-of-the-money for the no-arbitrage condition to hold. We remove all stock-day-expiration combinations if this condition is not satisfied. The details of our implementation are described in Appendix A1 . The volatility of the RND ($Volatility^{RND}$), which is annualized standard deviation of the log return distribution, is computed by taking the square root of Var^{RND}.

$$Volatility^{RND} = \sqrt{Var^{RND}} \tag{7}$$

3.2.2. Relative volume of OTM Calls and Puts

To estimate the relative volume of OTM call and put options, we first categorize the option contracts into ATM, OTM, and ITM based on their moneyness. We define call (put) options contract moneyness as the ratio of strike price and futures price (future price and strike price). Following Xing et al. (2010), options contracts (both call and put) with moneyness between 1.05 to 1.20 are categorized as OTM options, and those with moneyness between 0.95 to 1.05 is categorized as ATM options. The following two ratios are then computed to measure the relative volume of OTM call and put options.

$$OTMCE\_Ratio_{i,t} = \frac{Total\ Volume\ OTM\ Call_{i,t}}{Total\ Options\ Volume_{i,t}} \tag{8}$$

$$OTMPE\_Ratio_{i,t} = \frac{Total\ Volume\ OTM\ Put_{i,t}}{Total\ Options\ Volume_{i,t}} \tag{9}$$

where, $Total\ Volume\ OTM\ Call_{i,t}$ ($Volume\ OTM\ Put_{i,t}$) is the total volume of all OTM call (put) contracts written on stock i on day t and $Total\ Options\ Volume_{i,t}$ is the total volume across all option contracts written on stock i on day t. Both the measures range between 0 to 1, with a higher value of indicating a higher proportion of OTM options contracts relative to ATM and ITM options.

3.3. Approach and Breakthrough Period

We construct two variables to measure the distance of stock price from its 52W-H/L for each stock-day using the ratios given below. The 52*W High Ratio* (52*W Low Ratio*) measure is used to measure the stock's price distance from the 52W-H (52W-L) price.

$$52W\ High\ Ratio_{i,t} = \frac{Close\ Price_{i,t}}{52W\text{-}\ H\ Price_{i,t}} \tag{10}$$

$$52W\ Low\ Ratio_{i,t} = \frac{52W\text{-}\ L\ Price_{i,t}}{Close\ Price_{i,t}} \tag{11}$$

where, $Close\ Price_{i,t}$ is stocks' i adjusted closing price on day t, $52W\text{-}\ H\ Price_{i,t}$ ($52W\text{-}\ L\ Price_{i,t}$) is the highest (lowest) adjusted price of stocks' i over the past 52 weeks $(t - 252, t)$.[9] Both the measures lie between 0 and 1, with higher values indicating nearness to 52W-H/L and value of 1 indicating formation of a new 52W-H/L, which we label accordingly.

Next, the identification of 52W high and low days that serve as an anchor or reference point or grab investors' attention necessitates some subtle consideration. Because, new 52W-H/L very close to an earlier 52W-H/L is unlinkely to serve as a reference point, anchor, or attract investors' attention, we ignore new 52W-H/L occurring within 20 days of an earlier 52W-H/L date, in line with Driessen et al. (2013). As a result of this, our 52W-H/L dates for each stock are separated by at least 20 trading days. [10] We found 1,547 52W-H events and 1,030 52W-L events using the above identification strategy in our sample. For each 52W-H/L event, the five trading days before and after the event date are defined as approach period and the breakthrough period, respectively.

3.4. Control Variables

We use a set of control variables that are known to influence options' price and volume. Following the literature, we control for the following variables. Idiosyncratic volatility (IVOL) is the standard deviation of the daily idiosyncratic return estimated by regressing daily stock returns on the Fama and French (1993)-Carhart (1997) four-factor

[9]The use of adjusted closing price instead of the raw closing price of stocks neutralizes the effect of any stock splits or dividend payout events over the two ratios.

[10]One may choose a different cut-off period to identify fresh 52W-H/L event-days. While a higher cut-off reduces the number of events, a lower cut-off decreases the relevance of 52W high (low) days as an anchor, reference point or attention-grabbing event. For robustness analysis, we use a different cut-off day assumption (30 days) and find that the baseline results are qualitatively similar.

daily return within a month. SIZE is the logarithm of the market capitalization of stocks in million rupees (Indian). RET (20) is defined as the cumulative return of the last 20 days. P/C is the ratio of put and call options volume. ISKEW is the skewness of the daily idiosyncratic return estimated by regressing daily stock returns on the Fama and French (1993) and Carhart (1997) four-factor daily return within a month. Book-to-market ratio (BbyM) is the ratio of the book value and the market value of equity. Leverage is the ratio of total debt to the market value of the equity. Stock Price is the log of the stock price. Share turnover (SHRTURN) is the ratio of the average daily trading volume and the average shares outstanding in the month. Institutional Percentage is the percentage of total share held by institutional investors.

3.5. Summary Statistics

Table 2 reports the summary statistics of our sample and Table 3 shows the correlation between the variables. To remove outliers, we winsorize all of our variables at 1 and 99 percentile. The average $Volatility^{RND}$ for our sample is 0.38, which is very close to the average implied volatility value of ATM options reported in the Indian market by previous studies (Agarwalla et al., 2022). The mean value of $Skew^{RND}$ is -0.12, confirming the finding in the literature that option-implied RND is typically negatively skewed. The average values of $OTMCE\_Ratio$ and $OTMPE\_Ratio$ are 0.219 and 0.099, indicating that 21.9% and 9.9% of the total options volume are OTM call and puts, respectively. The large difference (≈12%) between OTM call and put volume in the Indian equity options market is noteworthy which may be pointing towards less usage of SSO for insurance purposes by investors.[11]

4. Empirical Specification

It is likely that the results observed in univariate analysis (plotting average value of variables of interest around 52W-H/L events) may be driven by some other factors that are known to influence the moments of the RND and the OTM options volume. To

[11] The evidence of high volume in OTM call with respect to OTM put is consistent with the finding of Bollen and Whaley (2004) in the US market.

confirm that the observed trends seen in the plots are not subsumed by any of the known factors in the literature, we use panel data regression methodology with fixed effects. To keep the model simple and tractable, while examining the behavior of dependent variables (moments of RND and relative volume of OTM calls and puts) around 52W-H/L, we estimate the following two panel regression equations with firm fixed effects for the approach period and the breakthrough period, respectively.

$$Var_{i,t} = \sum_{j=-5}^{0} \alpha_j t + j + \sum_{j=1}^{n} \beta_i Control_{j,t-1} + \delta_i + \epsilon_{i,t} \tag{12}$$

$$Var_{i,t} = \sum_{j=0}^{5} \alpha_j t + j + \sum_{j=1}^{n} \beta_i Control_{j,t-1} + \delta_i + \epsilon_{i,t} \tag{13}$$

where, $Var_{i,t}$ denotes $Volatility^{RND}$, $Skew^{RND}$, $OTMCE\_Ratio$, and $OTMPE\_Ratio$. $t+j$ is a dummy variable that takes the value 1 for j^{th} day before/after the formation of new 52W-H/L. The values of $t-5$ day and t day are used as the base for the approach period model and breakthrough period model, respectively. Therefore, the coefficients of the day dummy variables would reflect the average difference in the value of the dependent variables with respect to $t-5$ and t date, respectively in equation 12 and 13. $Control_{j,t-1}$ are various control variables like IVOL, SIZE, RET (20), P/C, ISKEW, BbyM, Leverage, Stock Price, SHRTURN, and Institutional Percentage (see Table A1) for variable definition). δ_i is firm-level fixed effects.

We estimate the equation 12 (13) separately for 52W high and low events and for the approach (breakthrough) periods. The coefficients of day dummies (α_i) are of interest to us. Their sign and statistical significance would reflect the trend of dependent variables and their significance in the approach/ breakthrough period.

5. Results and Discussion

In this section, we discuss the empirical evidence of the influence of approaching and breaking through 52W-H/L over moments of RND and the relative volume of OTM call and put options.

5.1. Behavior around 52W High

5.1.1. Univariate Analysis

We plot the trends of the mean value of the variables of interest ($Volatility^{RND}$, $Skew^{RND}$, $OTMCE\_Ratio$, and $OTMPE\_Ratio$) across all 52W-H events in a ±5 days event window (denoted by "Relative Day") around the 52W-H event. Figure 1 show the trend of $Volatility^{RND}$ and $Skew^{RND}$ around 52W-H event. The RND volatility (plot a) increases significantly as we move from the approaching period to the breakthrough period. The average volatility increases from 0.34 to 0.36 on the event date and remains elevated after the stock price breakthroughs the previous 52W-H, supporting the attention theory, which predicts an increase in the volatility after the breakthrough due to increased investors' attention.

Plot (b) of Figure 1 shows RND becomes negatively skewed ($Skew^{RND}$) leading up to 52W-H day. After the stock price breakthrough the past 52W-H, the trend reverses and RND becomes less negatively skewed. The average value of $Skew^{RND}$ decreases monotonically from just over -0.2 on five days before the event to a just under -0.3 on the event day and then returns to the same level in the following five days. Intuitively, the trend of $Skew^{RND}$ around 52WH event indicates that the price differential between OTM puts and calls begins to widen, making RND more negatively skewed as the event day approaches. Following the breakthrough, the trend reverses and the price differential between OTM puts and calls narrows, making RND less negatively skewed. This anchoring theory explains this behavior. Investors treat past 52W high prices as the salient anchor when approaching the 52W-H event day, and are reluctant to bid the price high even if the information justifies it. This shows up in the options market as buying pressure on OTM put options, causing RND to become more negatively skewed leading to the event day. Eventually, when a new 52W-H is formed due to the incorporation of positive news, investors are forced to upwardly revise their beliefs about stock price. This manifests in the options market as strong buying pressure for OTM call options, thereby reducing the RND's negative skew. Our findings, thus, provides preliminary evidence in the favour of investors' belief distortion when the stock price is near 52W-H.

Insert Figure 1 here

Plots (a) and (b) of Figure 2 show the trend of OTM call ($OTMCE\_Ratio$) and OTM put ($OTMPE\_Ratio$) volumes around the 52W-H events, respectively. The OTM call (put) options volume ratio show a decreasing (increasing) trend leading up to the 52W-H event day and the trend then reverses after the breakthrough. This behavior of OTM call and put options volume ratio confirm the prediction of anchoring theory (subsection 2.2). While approaching 52W-H event day investors treat past 52W-H price as a salient anchor and are reluctant to bid the price high even if the information justifies it. This manifests itself in the options market as buying (selling) pressure on OTM put (call) options. Eventually, when a new 52W-H is formed after the incorporation of good news, investors are forced to upwardly revise their beliefs regarding stock price. This manifests itself in the options market as buying (selling) pressure on OTM call (put) options. Hence, the OTM options volume dynamics around 52W-H are consistent with the behavior of RND skewness, confirming investors' belief distortion.

Insert Figure 2 here

5.1.2. Regression Analysis

The output of the regression models (equation 12 and 13) where $Volatility^{RND}$ (columns 1 and 2) and $Skew^{RND}$ (columns 3 and 4) are dependent variables is shown in Table 4. Columns 1 and 3 (2 and 4) report the approach (breakthrough) period regression model coefficients and standard errors (in parenthesis) for $Volatility^{RND}$ and $Skew^{RND}$, respectively. As mentioned earlier, we use the values of $t-5$ day and t day as the base for the approach and breakthrough period models, respectively. Therefore, the coefficients of days dummy variables reflects the average difference in the value of the dependent variables with respect to the base dates ($t-5$ and t date, respectively for approach and breakthrough models).

For the approach period (column 1), the average volatility for day t (0.010 with t-statistics of 3.33) is only statistically significantly different from day $t-5$, but not on other days ($t-4$ to $t-1$). Post the breakthrough (column 2), all the coefficients are negative and statistically significant, indicating reduction of average volatility after the breakthrough ($t+1$ to $t+5$ period). Taken together, the results for $Volatility^{RND}$ are consistent with the trends reported in part (a) of Figure 1 and provide evidence of increased volatility due to investors' heightened attention on new 52W-H trading days.

As regards RND Skewness, the coefficients of trading days $t-2$ to t are negative and statistically significant, indicating a decrease in the skewness as the price approaches the past 52W-H (column 3). For the breakthrough phase, the coefficients for all the five days ($t+1$ to $t+5$) are positive and statistically significant, indicating that the average skewness is greater than on date t. The results indicates that our preliminary findings from the univariate analysis (Figure 1 (plot b)) are robust, even after controlling for variables that are known to influence the RND skewness and firm-level fixed effects, thereby providing strong empirical evidence in the favour of investors' belief distortion around 52W-H.

Table 5 shows the estimated coefficients and the standard errors from the regression models separately for the approaching and the breakthrough period and with $OTMCE\_Ratio$ (columns 1 and 2) and $OTMPE\_Ratio$ (column 3 and 4) as dependent variables. In the approaching period, the coefficients of OTM call volume ($t-2$ to t) are negative and statistically significant (column 1), while the coefficients of OTM put volume ($t-4$ to t) are positive and statistically significant (column 3), indicating a decrease in the volume of the OTM call options and increase in the volume of OTM put options as the stock price approaches the past 52W-H. The breakthrough period results are opposite. The OTM call options volume increases (column 2) and the OTM put volume decreases (column 4) after the breakthrough date. The regression results indicate that the univariate results depicted in Figure 2 are robust, thereby providing strong empirical evidence in the favour of investors' belief distortion around 52W-H.

Insert Tables 4 and 5 here

5.2. Behavior around 52W Low

5.2.1. Univariate Analysis

Figure 3 show the trend of $Volatility^{RND}$ and $Skew^{RND}$ around 52W-L event, respectively. The volatility of the RND (plot (a)) jumps as we move from the approaching period to the breakthrough period. The average volatility increases from just over 0.42 on day $t-1$ to just under 0.48 on the event date and remains elevated after it indicating increased investors' attention after the breakthrough. The skewness of the RND remains positive and shows an increasing trend leading to 52W-L day and after the breakthrough, the trend reverses and RND becomes negatively skewed (plot (b)). The average $Skew^{RND}$ almost monotonically increases from 0.02 on day $t-5$ to 0.15 on the event day, and then monotonically falls after the stock price breakthroughs the past 52W-L to -0.06 in $t+5$. Intuitively, the trend of $Skew^{RND}$ around 52W-L reflects that the price differential between OTM calls and puts start to increase making RND positively skewed while approaching the event day, and reduces after the breakthrough making RND more negatively skewed. This behavior is explained by the anchoring theory. While approaching 52W-L event day, the investors treat past 52W-L price as a salient anchor and are reluctant to bid the price lower even if the information justifies it. This manifests in the options market as buying pressure on OTM call options leading to the event day making RND positively skewed. Eventually, when a new 52W-L is formed due to the incorporation of bad news, the investors' are forced to downwardly update their beliefs about the stock price. This manifests in the options market as high buying pressure of OTM put options making the RND more negatively skewed. Thus, part (b) of Figure 3 provides preliminary evidence in the favour of investors' belief distortion when the stock price approaches 52W-L.

Insert Figure 3 here

Figure 4 shows the trend of OTM call ($OTMCE\_Ratio$) and OTM put ($OTMPE\_Ratio$) volume surrounding the 52W-L event. The OTM call option volume ratio (plot a) increases monotonically leading up to the 52W-L event day, but then reverses the direction after the breakthrough. In contrast, the OTM put options volume ratio (plot b) shows no trend leading up to the 52W-L day, but then spikes after the breakthrough date and remains elevated for the next five days. The trend of the OTM call and put volume ratios confirm the prediction of anchoring theory, according to which investors regard the previous 52W-L price as a salient anchor and are reluctant to bid the price low even if the information justifies it. This manifests as buying (selling) pressure on OTM call (put) options. Eventually, when a new 52W-L is formed after the incorporation of negative news, investors are forced to update their beliefs to the downside, which manifests itself as buying (selling) pressure of OTM put (call) options. Therefore, when the stock price approaches 52W-L, the dynamics of OTM options volume are consistent with the behavior of RND skewness, confirming investors' belief distortion.

Insert Figure 4 here

5.2.2. Regression Analysis

The output of the regression models (equation 12 and 13) where $Volatility^{RND}$ (columns 1 and 2) and $Skew^{RND}$ (columns 3 and 4) are dependent variables is shown in Table 6. Columns 1 and 3 (2 and 4) report the approach (breakthrough) period regression model coefficients and standard errors for $Volatility^{RND}$ and $Skew^{RND}$, respectively. The coefficients of days dummy in approach and breakthrough period models, as before, show the average difference in the value of dependent variables with respect to $t-5$ and t dates, respectively.

In the approach period (column 1), the average volatility is statistically different only on day t, but not for other days (day $t-4$ to $t-1$). In the breakthrough period (column 2), the coefficients of $t+1$ and $t+2$ are negative and statistically significant, indicating lower average volatility after the breakthrough. Taken together, the results of $Volatility^{RND}$ are consistent with the trends reported in part (a) of Figure 3 and show increased volatility indicating greater investors' attention on days when new 52W lows are formed.

As regards the average skewness of the RND, in the approach period (column 3) the coefficients of trading days $t-3$ to t are positive and significant but in the breakthrough period (column 4), the coefficients of all the five trading days ($t+1$ to $t+5$) are negative and significant, indicating a gradual decrease in the skewness after the breakthrough. Overall, the results establishes the robustness of the univariate relationship reported in plot (b) of Figure 3, providing strong evidence in favor of investors' belief distortion around 52W-L.

Table 7 shows the coefficients and standard errors estimated using regression model specified in equation 12 and 13) with $OTMCE\_Ratio$ (columns 1 and 2) and $OTMPE\_Ratio$ (columns 3 and 4) as dependent variables. In the approach period, the coefficients of the OTM call options volume ratio are positive and statistically significant only for days $t-3$ to t (column 1), indicating increase in volume of OTM call options just before the breakthrough date. The OTM put options volume ratio is somewhat muted before the event date. The coefficient is negative and significant only for day t. On the contrary, the coefficients for all the five trading days following the 52W-L breakthrough (day $t+1$ to $t+5$) are negative and statistically significant for OTM call options (column 3) but positive and statistically significant for OTM put options (column 4), indicating a decrease in OTM call options volume and increase in OTM put options volume relative to the new 52W-L date. Overall, the regression results establishes that the OTM volume trends seen in Figure 4 are robust after controlling for a battery of control variables and firm-level fixed effects, thereby providing evidence of investors' belief distortion around 52W-L.

Insert Tables 6 and 7 here

6. Robustness

We conduct additional analysis to examine the robustness of our results. First, instead of using moments of RND to capture the investors' risk attitude and belief near 52W-H/L, we use the level and slope of the implied volatility (IV) curve. It is known that the level and the slope of IV curve are highly correlated with the volatility and skewness of the RND (Bakshi et al., 2003). We measure the level of the IV curve as the IV of at-the-money options (ATM-IV) and slope as the difference between IV of OTM call and put normalized by ATM-IV. The detailed estimation procedure is explained in Annexure A2.

Similar to our main analysis, we conduct both univariate as well as regression analysis for 52-W high and low events separately. Figure A1 shows the trend of level and slope of IV curve, and Table A2 reports the regression results of equation 12 and 13 for 52W-H. We find both univariate and regression results to be qualitatively similar to what we report in Figure 1 and Table 4. Similarly, Figure A2 shows the trend of level and slope of IV curve and Table A3 reports the regressions results for 52W-L. Both univariate and regression results for level (ATM-IV) of IV curve are similar to $Volatility^{RND}$ results reported in the primary analysis (Figure 3(a) and Table 6 (Columns 1 and 2). However the regression results where the slope of IV curve is used as the dependent variable are weakened, though the broad trend remains the same i.e., there is a sharp drop in the slope of IV curve after the stock price breaches the old 52W-L. Taken together, this findings show that our primary result of belief distortion around 52W-H/L is independent of the method used to estimate RND moments.

Second, we replicate our baseline results reported in Table 4 to 7 after changing the 20 days separation period criteria between two consecutive 52W-H/L (see subsection 3.3) to 10 and 30 days. The results are not reported for brevity's sake, but we find that the baseline results remain qualitatively similar even with the new criterion.

7. Conclusion

Past research on the behavior of the financial market around 52W-H/L has primarily focused on the spot market, with only a few studies looking at the behavior of the options market. However, the options market is both forward-looking and captures the investors' risk preference, making it an ideal place to examine investors' risk attitude and future expectations near 52W-H/L. Our study fills this gap in the literature by first predicting the behavior of options market variables like moments of RND and options volume, which are known to reflect investors' risk attitude and future expectations. We do so by using theories such as prospect theory, anchoring theory, and investor attention hypothesis, which have been proposed to explain the effect of 52W-H/L. Second, we empirically examine the behavior of these options market variables near the 52W-H/L to see which theory best explains the behavior. For this we use data from the Indian single stock options market, which is one of the most liquid options markets in the world with high retail investors participation, making it uniquely suited for the study.

We investigate the behavior of our variables of interest in an event study setting around 52W-H/L. Our empirical analysis provides the following key results. First, consistent with the prediction of attention theory, both univariate and regression analysis show that volatility of RND increases sharply as the share price crosses past 52W-H/L. Second, in line with the prediction of anchoring theory, we find that as stock price approaches 52W high (low), the skewness of the RND and OTM call volume decreases (increases), and OTM put volume increases (decreases). Third, again in line with the anchoring theory, we find that during the breakthrough period of 52W high (low), the skewness of the RND and OTM call volume increases (decreases), while the OTM put volume decreases (increases).

Our results, both in the approach and breakthrough period, are explained by anchoring theory which predicts that investors' belief about the future price will be distorted near 52W-H/L. Overall, our findings show that options investors, who are sometimes considered more sophisticated than spot investors, have behavioral biases. This is not surprising given the widespread use of options by meme stock investors across the world in recent years, and also the significant role of retail investors in the Indian options market since its inception.

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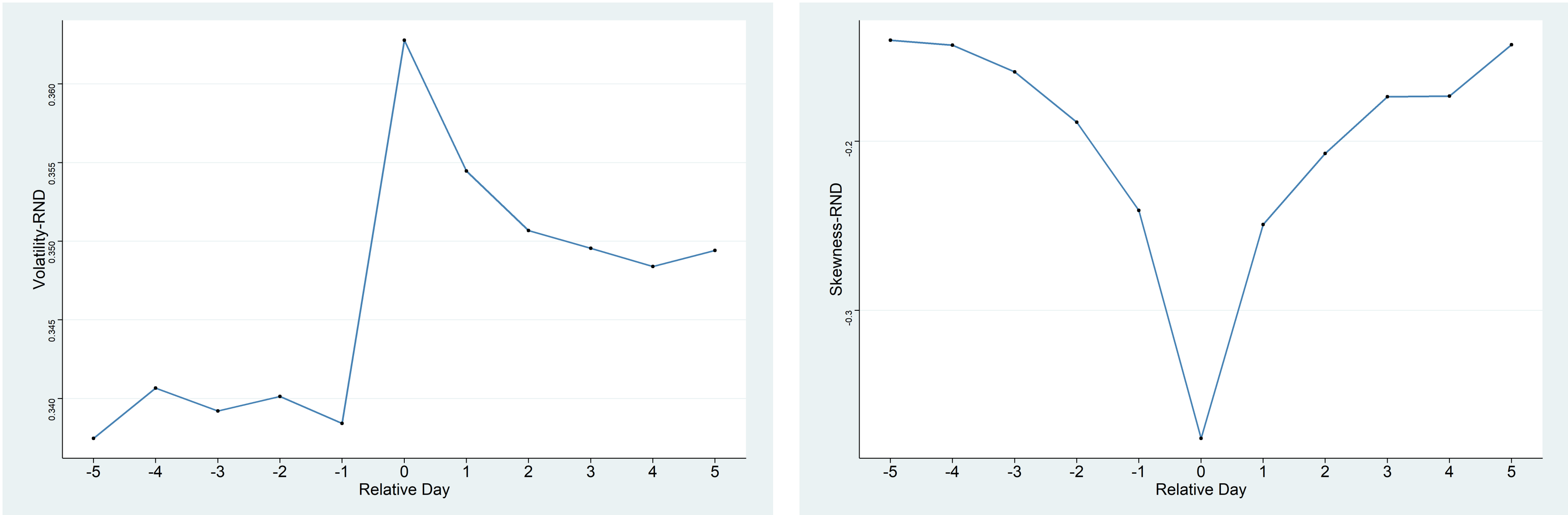
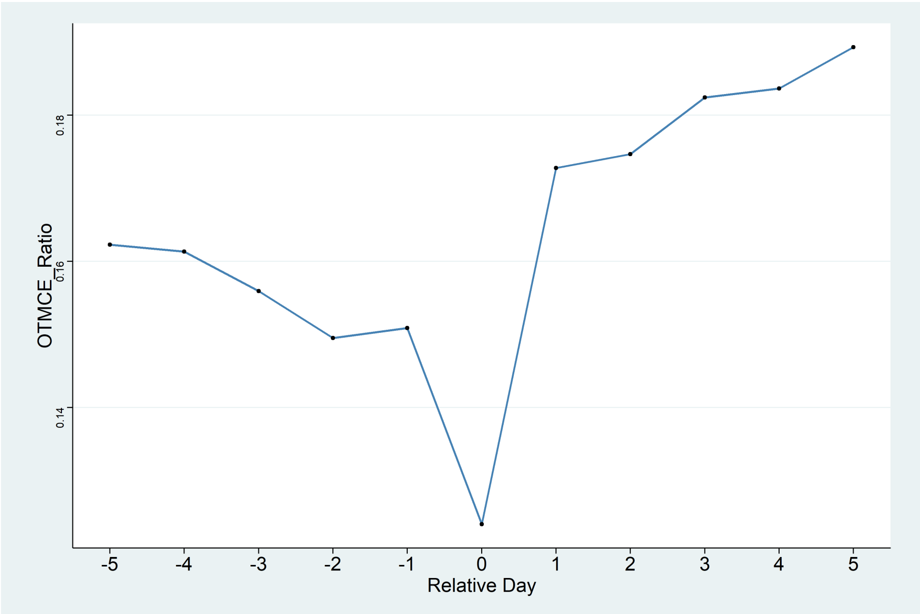
Figure 1: RND moments around 52W high



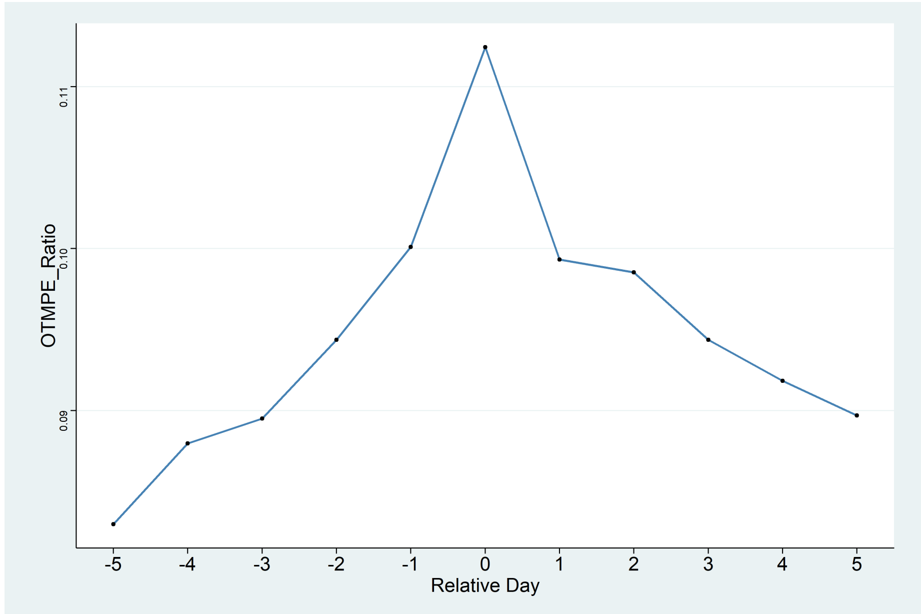
(a) (b)

The figures show the pattern of equally-weighted mean of volatility (plot a) and skewness (plot b) of risk-neutral-density (RND) in a ±5 days window around the trading day when the stock price hits a new 52W-high (Relative day = 0). The sample spans from January 2011 to December 2019.

Figure 2: OTM call and put volume ratio around 52W high



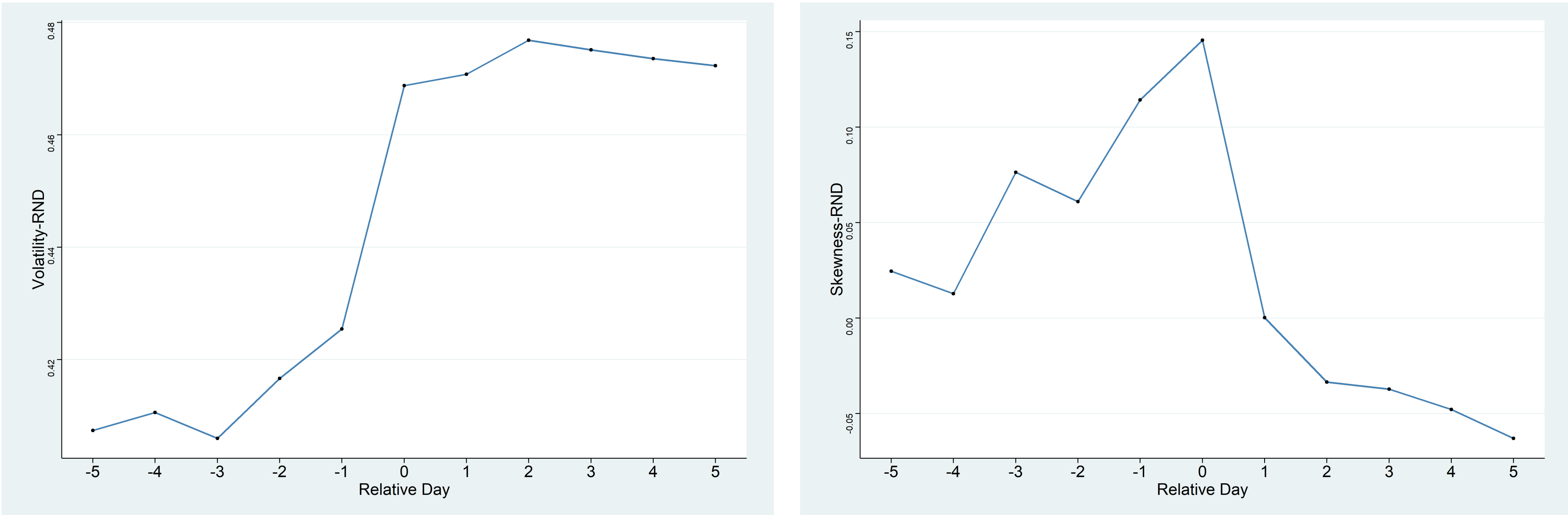
(a)



(b)

Figures (a) and (b) show the pattern of equally-weighted mean of OTM call ($OTMCE\_Ratio$) and put ($OTMPE\_Ratio$) options volume ratios, in a ± 5 days window around the trading day when a new 52W-high is formed (Relative day $=0$), respectively. The sample spans from January 2011 to December 2019.

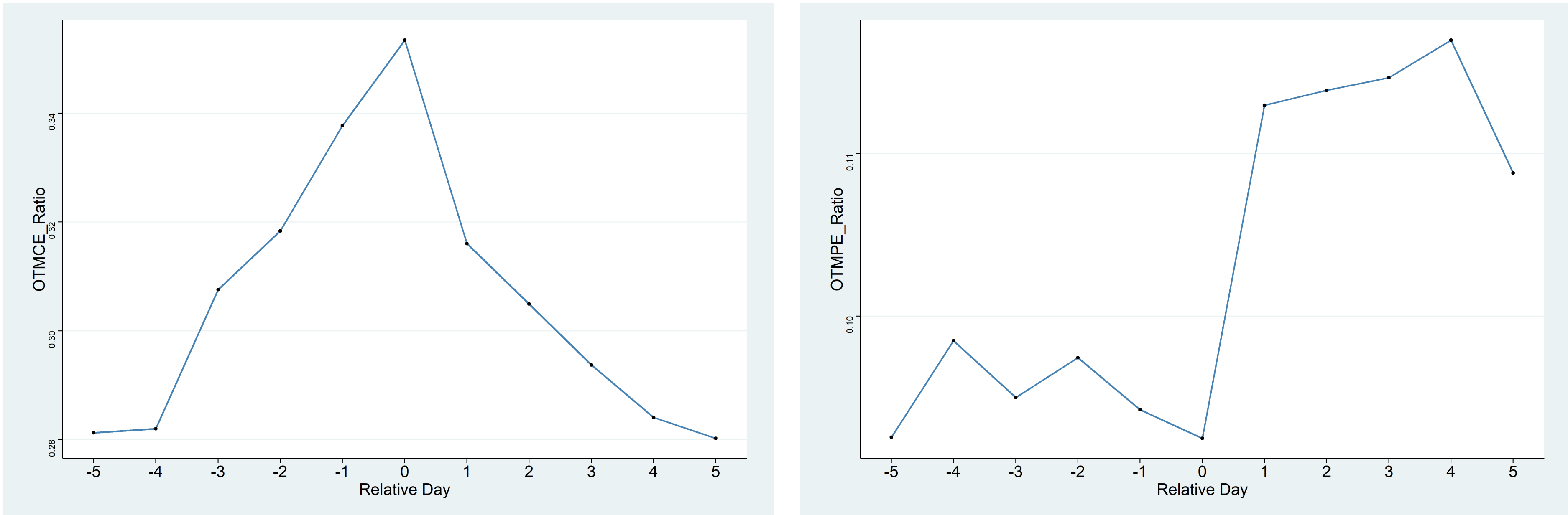
Figure 3: RND Moments around 52W low



(a) (b)

The figures show the pattern of equally-weighted mean of volatility (plot a) and skewness (plot b) of risk-neutral-density (RND) in a ± 5 days window around the trading day when the stock price hits a new 52W-low (Relative day $= 0$). The sample spans from January 2011 to December 2019.

Figure 4: OTM Call and Put volume ratio around 52W low



(a) (b)

Figures (a) and (b) show the pattern of equally-weighted mean of OTM call ($OTMCE\_Ratio$) and put ($OTMPE\_Ratio$) options volume ratios, in a ±5 days window around the trading day when a new 52W-low is formed (Relative day =0), respectively. The sample spans from January 2011 to December 2019.

Table 2: Summary Statistics

Statistic	N	Mean	St. Dev.	Minimum	Pctl(25)	Median	Pctl(75)	Maximum
$Volatility^{RND}$	18,162	0.387	0.140	0.184	0.290	0.357	0.451	0.868
$Skew^{RND}$	18,162	−0.120	0.477	−1.312	−0.418	−0.128	0.171	1.242
OTMCE_Ratio	16,003	0.219	0.155	0.006	0.091	0.192	0.324	0.642
OTMPE_Ratio	16,014	0.099	0.067	0.003	0.048	0.086	0.137	0.315
52W High Ratio	18,129	0.834	0.203	0.233	0.673	0.961	0.993	1.000
52W Low Ratio	18,129	0.757	0.196	0.279	0.603	0.738	0.968	1.000
Ivol	17,835	0.017	0.007	0.008	0.012	0.015	0.019	0.045
SIZE	17,835	12.479	1.236	9.760	11.576	12.496	13.327	15.167
RET (20)	17,835	0.017	0.120	−0.245	−0.062	0.026	0.091	0.324
P/C	18,162	0.463	0.262	0.083	0.273	0.415	0.592	1.379
Iskew	17,835	0.244	0.756	−2.025	−0.189	0.229	0.667	2.329
BbyM	17,801	0.608	0.643	0.024	0.196	0.350	0.769	3.156
Leverage	17,071	1.139	1.728	0.019	0.119	0.425	1.339	9.432
Stock Price	18,162	5.576	1.202	0.875	4.766	5.608	6.413	8.158
SHRTURN	17,835	0.093	0.118	0.008	0.030	0.055	0.105	0.809
Institutional Percentage	17,835	34.102	14.722	7.260	23.800	32.089	42.225	86.910
Put-call parity	17,868	0.0001	0.022	−0.343	−0.009	−0.0003	0.009	0.332
IVSKEW	16,163	−0.026	0.111	−0.351	−0.089	−0.025	0.037	0.318

The table reports the number of observations (N), mean, standard deviation (St. Dev.), minimum, quartiles (25^{th} percentile, median, and 75^{th} percentile), and maximum values of variables used in the study. Table A1 provides the variables definition. The sample period spans from January 2011 to December 2019. All the variables are winsorized at the 1^{st} and 99^{th} percentile.

Table 3: Correlation Table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) $Volatility^{RND}$	1															
(2) $Skew^{RND}$	0.038	1														
(3) OTMCE_Ratio	0.402	0.414	1													
(4) OTMPE_Ratio	0.195	-0.366	-0.085	1												
(5) 52W High Ratio	-0.499	-0.234	-0.480	-0.065	1											
(6) 52W Low Ratio	0.175	0.241	0.356	-0.013	-0.789	1										
(7) IVOL	0.458	-0.016	0.194	0.113	-0.213	-0.059	1									
(8) SIZE	-0.551	-0.211	-0.370	-0.063	0.375	-0.075	-0.348	1								
(9) RET (20)	-0.262	-0.195	-0.295	-0.027	0.746	-0.716	-0.003	0.165	1							
(10) ISKEW	-0.029	-0.030	-0.034	-0.018	0.213	-0.232	0.081	-0.050	0.248	1						
(11) P/C	-0.037	-0.311	-0.182	0.431	-0.070	0.121	-0.060	0.270	-0.055	-0.070	1					
(12) BbyM	0.467	0.125	0.338	0.109	-0.539	0.312	0.143	-0.442	-0.331	-0.031	-0.034	1				
(13) Leverage	0.350	0.079	0.225	0.072	-0.387	0.193	0.121	-0.341	-0.222	-0.038	-0.024	0.685	1			
(14) Stock Price	-0.470	-0.180	-0.392	-0.080	0.368	-0.178	-0.215	0.473	0.191	-0.015	0.181	-0.560	-0.430	1		
(15) SHRTURN	0.445	0.004	0.186	0.076	-0.243	-0.053	0.499	-0.538	-0.045	0.013	-0.067	0.308	0.226	-0.142	1	
(16) Institutional Percentage	-0.205	-0.095	-0.157	-0.052	0.160	-0.070	-0.139	0.123	0.049	-0.032	0.084	-0.156	-0.116	0.241	0.048	1
(17) IVSKEW	-0.096	0.628	0.100	-0.221	0.113	-0.083	-0.036	-0.065	0.108	0.045	-0.346	-0.022	-0.035	-0.079	-0.044	-0.070

The table reports the correlation between the variables used in the study. Table A1 provides the variables definition. The sample period spans from January 2011 to December 2019. All the variables are winsorized at the 1^{st} and 99^{th} percentile.

Table 4: Volatility and Skewness of RND around 52W high

Dependent variable:	$Volatility^{RND}$		$Skew^{RND}$	
	(1)	(2)	(3)	(4)
t-4	0.003		−0.002	
	(0.004)		(0.019)	
t-3	−0.0001		−0.010	
	(0.004)		(0.019)	
t-2	0.0003		−0.042**	
	(0.004)		(0.018)	
t-1	−0.004		−0.103***	
	(0.004)		(0.018)	
t	0.010***		−0.277***	
	(0.003)		(0.017)	
t+1		−0.006**		0.206***
		(0.003)		(0.015)
t+2		−0.010***		0.276***
		(0.003)		(0.016)
t+3		−0.009***		0.311***
		(0.003)		(0.016)
t+4		−0.011***		0.312***
		(0.003)		(0.016)
t+5		−0.011***		0.335***
		(0.003)		(0.016)
Controls	Yes	Yes	Yes	Yes
Firm-level FE	Yes	Yes	Yes	Yes
Observations	5,529	6,437	5,529	6,437
Adjusted R^2	0.588	0.600	0.302	0.325

The table reports the 52W high panel data regression results of equation 12 (Columns (1) & (3)) and 13 (Columns (2) & (4)). Columns (1&2) and (3&4) report the results where volatility ($Volatility^{RND}$) and skewness ($Skew^{RND}$) of the RND are dependent variables, respectively. Each column of the table shows the coefficients of the model and standard errors in parenthesis. Controls include IVOL, SIZE, RET (20), P/C, ISKEW, BbyM, Leverage, Stock Price, SHRTURN, and Institutional Percentage. Table A1 provides the variables definition. *, **, and *** represent statistical significance at 10%, 5%, and 1% levels, respectively. The sample period spans from January 2011 to December 2019.

Table 5: Volume OTM call and put options around 52W high

Dependent variable:	OTMCE_Ratio		OTMPE_Ratio	
	(1)	(2)	(3)	(4)
t-4	0.0001		0.006**	
	(0.006)		(0.003)	
t-3	−0.008		0.006**	
	(0.006)		(0.003)	
t-2	−0.016***		0.012***	
	(0.005)		(0.003)	
t-1	−0.018***		0.018***	
	(0.005)		(0.003)	
t	−0.055***		0.031***	
	(0.005)		(0.003)	
t+1		0.054***		−0.017***
		(0.005)		(0.002)
t+2		0.058***		−0.020***
		(0.005)		(0.002)
t+3		0.066***		−0.022***
		(0.005)		(0.002)
t+4		0.066***		−0.026***
		(0.005)		(0.002)
t+5		0.071***		−0.027***
		(0.005)		(0.003)
Controls	Yes	Yes	Yes	Yes
Firm-level FE	Yes	Yes	Yes	Yes
Observations	4,668	5,814	4,741	5,929
Adjusted R^2	0.366	0.350	0.183	0.229

The table reports the 52W high panel data regression results of equation 12 (Columns (1) & (3)) and 13 (Columns (2) & (4)). Column (1&2) and (3&4) reports the results where volume ratio of OTM call (OTMCE_Ratio) and put (OTMPE_Ratio) are dependent variables, respectively. Each column of the table shows the coefficients of the model and standard errors in parenthesis. Controls include IVOL, SIZE, RET (20), ISKEW, BbyM, Leverage, Stock Price, SHRTURN, and Institutional Percentage. Table A1 provides the variables definition. *, **, and *** represent statistical significance at 10%, 5%, and 1% levels, respectively. The sample period spans from January 2011 to December 2019.

Table 6: Volatility and Skewness of RND around 52W low

Dependent variable:	Vol RND		Skewness RND	
	(1)	(2)	(3)	(4)
t-4	−0.001		−0.001	
	(0.006)		(0.026)	
t-3	−0.005		0.064**	
	(0.006)		(0.026)	
t-2	−0.003		0.056**	
	(0.006)		(0.026)	
t-1	0.005		0.123***	
	(0.006)		(0.026)	
t	0.027***		0.217***	
	(0.005)		(0.024)	
t+1		−0.009**		−0.152***
		(0.004)		(0.021)
t+2		−0.009**		−0.205***
		(0.005)		(0.022)
t+3		−0.004		−0.234***
		(0.005)		(0.022)
t+4		−0.004		−0.239***
		(0.005)		(0.022)
t+5		−0.001		−0.268***
		(0.005)		(0.023)
Controls	Yes	Yes	Yes	Yes
Firm-level FE	Yes	Yes	Yes	Yes
Observations	3,496	4,040	3,496	4,040
Adjusted R^2	0.652	0.705	0.266	0.309

The table reports the 52W low panel data regression results of equation 12 (Columns (1) & (3)) and 13 (Columns (2) & (4)). Column (1&2) and (3&4) reports the results where volatility ($Volatility^{RND}$), and skewness ($Skew^{RND}$) of the RND are dependent variables, respectively. Each column of the table shows the coefficients of the model and standard errors in parenthesis. Controls include IVOL, SIZE, RET (20), P/C, ISKEW, BbyM, Leverage, Stock Price, SHRTURN, and Institutional Percentage. Table A1 provides the variables definition. *, **, and *** represent statistical significance at 10%, 5%, and 1% levels, respectively. The sample period spans from January 2011 to December 2019.

Table 7: Volume OTM call and put options around 52W low

Dependent variable:	OTMCE_Ratio		OTMPE_Ratio	
	(1)	(2)	(3)	(4)
t-4	0.001		0.004	
	(0.009)		(0.005)	
t-3	0.024^{***}		-0.001	
	(0.009)		(0.005)	
t-2	0.030^{***}		-0.001	
	(0.009)		(0.004)	
t-1	0.056^{***}		-0.005	
	(0.009)		(0.005)	
t	0.078^{***}		-0.012^{***}	
	(0.008)		(0.004)	
t+1		-0.055^{***}		0.020^{***}
		(0.007)		(0.004)
t+2		-0.062^{***}		0.017^{***}
		(0.007)		(0.004)
t+3		-0.075^{***}		0.018^{***}
		(0.007)		(0.004)
t+4		-0.081^{***}		0.022^{***}
		(0.007)		(0.004)
t+5		-0.091^{***}		0.013^{***}
		(0.007)		(0.004)
Controls	Yes	Yes	Yes	Yes
Firm-level FE	Yes	Yes	Yes	Yes
Observations	2,909	3,660	2,818	3,576
Adjusted R^2	0.226	0.220	0.177	0.143

The table reports the 52W low panel data regression results of equation 12 (Columns (1) & (3)) and 13 (Columns (2) & (4)). Columns (1&2) and (3&4) reports the results where volume ratio of OTM call (OTMCE_Ratio) and put (OTMPE_Ratio) are dependent variables, respectively. Each column of the table shows the coefficients of the model and standard errors in parenthesis. Controls include IVOL, SIZE, RET (20), ISKEW, BbyM, Leverage, Stock Price, SHRTURN, and Institutional Percentage. Table A1 provides the variables definition. *, **, and *** represent statistical significance at 10%, 5%, and 1% levels, respectively. The sample period spans from January 2011 to December 2019.

Annexure A - RND Moments, ATM-IV, and Slope of IV Curve Estimation

A1 . RND moments estimation

We implement a trapezoidal approach. For that we first define the strike differences for calls (puts) as $\Delta K_i^C = K_i^c - K_{i-1}^C$ for $i \in \{2....n_C\}$ and $\Delta_1^C = K_1^C - SSF^*$ ($_i^P = K_i^P - K_{i-1}^P$ for $i \in \{2....n_P\}$ and $\Delta K_1^P = SSF^* - K_1^P$). Where, n_C and n_P are number of call and put OTM contracts trading for each stock-date-expiration combination. We then approximate the BKM integration for V, X, and W as:

$$\begin{aligned} V_{i,t,\tau} = v_c(K_1^C)C_1\Delta K_1^C + \sum_{i=2}^{n_c}\frac{1}{2}[v_c(K_i^C)C_i + v_c(K_{i-1}^C)C_i]\Delta K_i^C + v_P(K_1^P)P_1\Delta K_1^P \\ + \sum_{i=2}^{n_P}\frac{1}{2}[v_P(K_i^p)P_i + v_p(K_{i-1}^p)P_i]\Delta K_i^P \end{aligned} \tag{14}$$

$$\begin{aligned} W_{i,t,\tau} = w_c(K_1^C)C_1\Delta K_1^C + \sum_{i=2}^{n_c}\frac{1}{2}[w_c(K_i^C)C_i + w_c(K_{i-1}^C)C_i]\Delta K_i^C - w_P(K_1^P)P_1\Delta K_1^P \\ - \sum_{i=2}^{n_P}\frac{1}{2}[w_P(K_i^p)P_i + w_p(K_{i-1}^p)P_i]\Delta K_i^P \end{aligned} \tag{15}$$

$$\begin{aligned} X_{i,t,\tau} = x_c(K_1^C)C_1\Delta K_1^C + \sum_{i=2}^{n_c}\frac{1}{2}[x_c(K_i^C)C_i + x_c(K_{i-1}^C)C_i]\Delta K_i^C - x_P(K_1^P)P_1\Delta K_1^P \\ - \sum_{i=2}^{n_P}\frac{1}{2}[x_P(K_i^p)P_i + x_p(K_{i-1}^p)P_i]\Delta K_i^P \end{aligned} \tag{16}$$

Where:

$$v_c(K) = \frac{2(1 - ln(K/SSF^*))}{K^2} \tag{17}$$

$$v_p(K) = \frac{2(1 + ln(SSF^*/K))}{K^2} \tag{18}$$

$$w_c(K) = \frac{6ln(K/SSF^*) - 3(ln(K/SSF^*))^2}{K^2} \tag{19}$$

$$w_p(K) = \frac{6ln(SSF^*/K) + 3(ln(SSF^*/K))^2}{K^2} \tag{20}$$

$$x_c(K) = \frac{12(ln(K/SSF^*))^2 - 4(ln(K/SSF^*))^3}{K^2} \tag{21}$$

$$w_p(K) = \frac{12(ln(SSF^*/K))^2 + 4(ln(SSF^*/K))^3}{K^2} \tag{22}$$

Plugging the values that we get from equations 14, 15, and 16 into equations 1, and 2 gives us discrete strike price-based model free estimation of the variance, and skewness of the risk-neutral-distribution of the stocks return.

A2. ATM-IV and Slope of IV smile estimation

To estimate the volatility of at-the-money (ATM) options and the slope of implied volatility (IV) smile, we use time-matched high-frequency data from both options and futures markets. Before starting the IV estimation we clean the data by broadly following Jain et al. (2019) and (Agarwalla et al., 2022). We first exclude all single stock options (SSO) contracts that have traded for less than five minutes in a day. We also remove contracts whose prices lay outside the Black models' arbitrage bound.

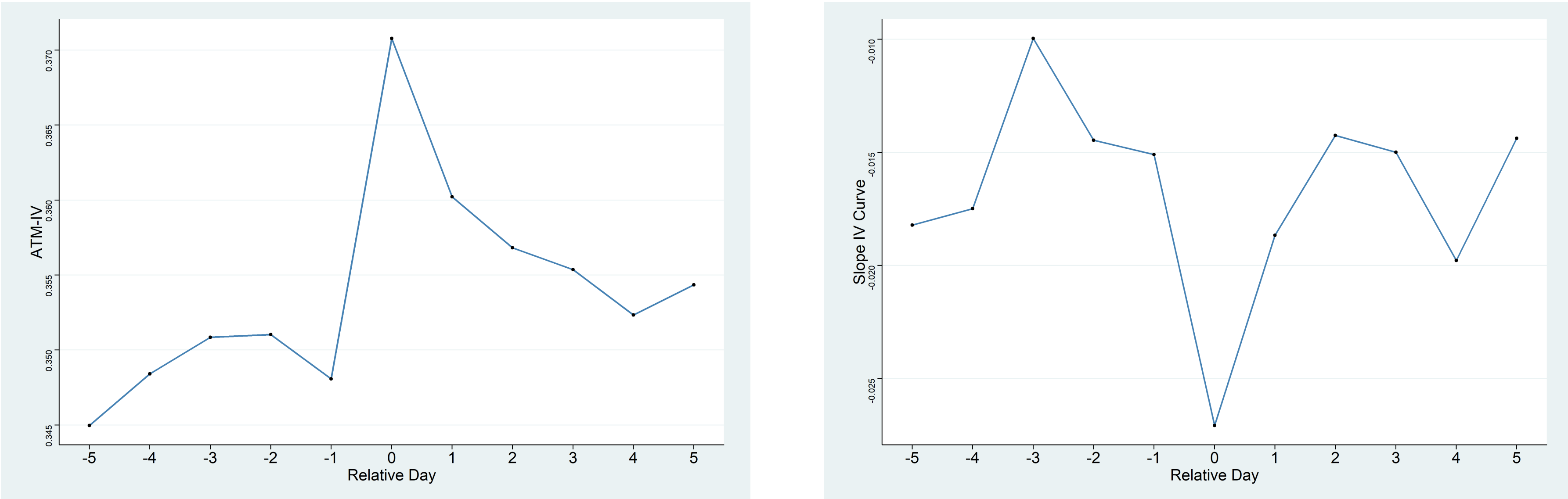
Next, we start with the implied volatility (IV) estimation of all the options contracts in our sample. India has liquid single stock futures (SSF) market that allows us to use the Black (1976) model for IV estimation. Previous studies in the Indian market have used a similar method to estimate IV (Jain et al., 2019; Agarwalla, Varma and Virmani, 2021a; Agarwalla et al., 2022; Agarwalla, Varma and Virmani, 2021b). The use of SSF price instead of spot price helps us to avoid the calculation of the cost of carry and dividend yield while doing IV estimation.

After IV estimation, we categorize all the options contracts in our sample into at-the-money (ATM), out-of-the-money (OTM), and in-the-money (ITM) based on their moneyness, which for call (put) options defined as strike price by futures price (futures price by strike price). Following Xing et al. (2010), we label a call or put option as OTM (ATM) if the moneyness of the contract lies between 1.05 and 1.20 (0.95 and 1.05). The rest of the options contracts are categorized as ITM. Using the aforementioned categorization scheme, we label every contract of an SSO-day pair into ATM or OTM, or ITM. It is possible to have more than one options contract in the ATM or OTM group of an SSO-day pair. So, to arrive at a single IV value for each group of an SSO-day pair we took the volume-weighted average of the IV of all the options contracts belonging to a particular group.

The above-mentioned steps give us IV of OTM, ATM, and ITM options for each SSO-day pair which we use to calculate ATM-IV and the slope of IV curve. ATM-IV is simply the IV of the ATM option for each SSO-day pair. The slope of IV smile is calculated as the difference between the IV of OTM call and OTM put normalised by ATM-IV for each SSO-day pair ($\frac{IV_{OTMCall} - IV_{OTMPut}}{ATM-IV}$).

Annexure B - Variable Definition and Robustness results

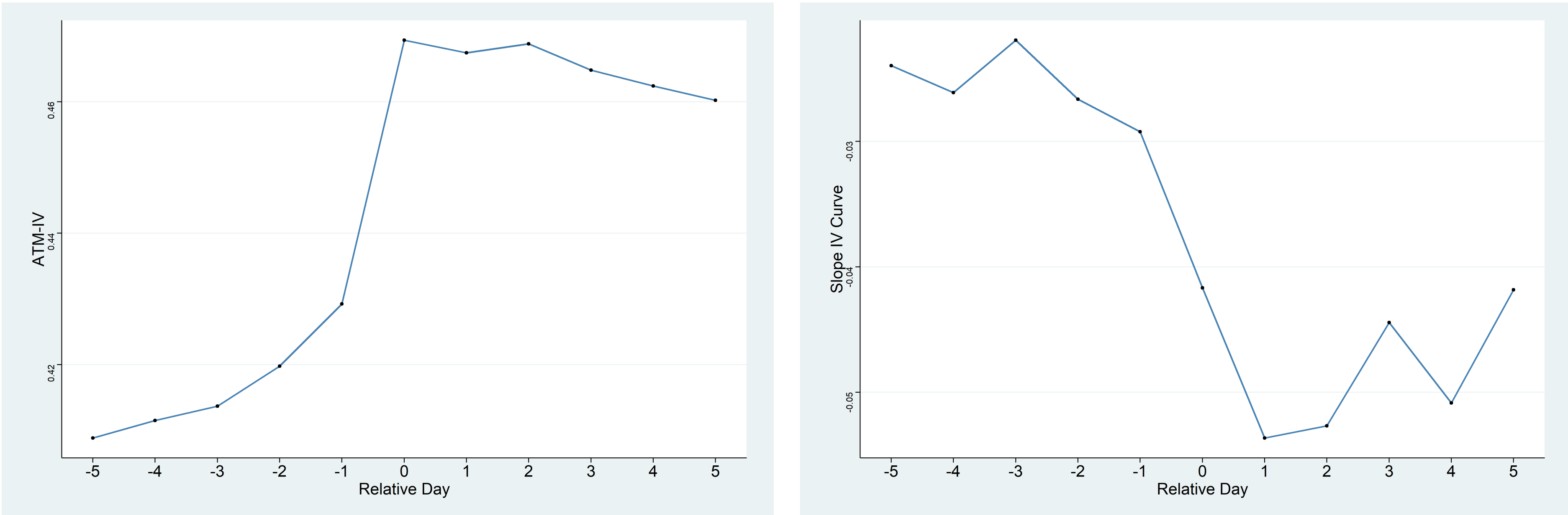
Figure A1 : Level and Slope IV Curve around 52W high



(a) (b)

The figures show the pattern of equally-weighted mean of level (plot a) and slope of IV curve (plot b) in a ±5 days window around the trading day when the stock price hits a new 52W-high (Relative day = 0). The sample spans from January 2011 to December 2019.

Figure A2 : Level and Slope IV Curve around 52W low



(a) (b)

The figures show the pattern of equally-weighted mean of level (plot a) and slope of IV curve (plot b) in a ±5 days window around the trading day when the stock price hits a new 52W-low (Relative day = 0). The sample spans from January 2011 to December 2019.

Table A1 : Variable Construction Details

Variable Name	Variable Definition	Source
$Volatility^{RND}$	Volatility of the RND estimated following Bakshi et al. (2003).	NSE Trading File
$Skew^{RND}$	Skewness of the RND estimated following Bakshi et al. (2003).	NSE Trading File
OTMCE_Ratio	Ratio of total volume of out-of-the-money call options ($1.05 \leq moneyness \leq 1.20$) and total options volume for a SSO-day pair.	NSE Bhav File
OTMPE_Ratio	Ratio of total volume of out-of-the-money put options ($1.05 \leq moneyness \leq 1.20$) and total options volume for a SSO-day pair.	NSE Bhav File
52W High Ratio	Ratio of stocks' adjusted closing price and 52 week high price	CMIE Prowess
52W Low Ratio	Ratio of stocks' adjusted closing price and 52 week low price	CMIE Prowess
IVOL	Standard deviation of the idiosyncratic return estimated by regressing daily returns of a stock on Fama and French (1993)-Carhart (1997) four factor daily return within a month.	CMIE Prowess
SIZE	Monthly average of the log of market capitalization in million rupees.	CMIE Prowess
RET (20)	Cumulative return in last 20 trading days	CMIE Prowess
ISKEW	Skewness of the idiosyncratic return estimated by regressing daily returns of a stock on Fama and French (1993)-Carhart (1997) four factor daily return within a month.	CMIE Prowess
P/C	Ratio of total put volume to total call volume of a stock.	NSE Bhav File
BbyM	Ratio of firms' book value of the equity to its market value, and then averaged over the month.	CMIE Prowess
Leverage	Ratio of total external debt to market value of the equity.	CMIE Prowess
Stock Price	Log of the price of the stock.	CMIE Prowess

Table A1 : Variable Construction Details

Variable Name	Variable Definition	Source
SHRTURN	Ratio of average daily trading volume in a month and share outstanding in the month	CMIE Prowess
Institutional Percentage	Percentage of total share held by institutional investors	CMIE Prowess
ATM-IV	Implied volatility of at-the-money options	NSE Trade File
Slope of IV Curve	Ratio of difference between the IV of OTM Call ($1.05 \leq moneyness \leq 1.20$) and OTM PUT ($1.05 \leq moneyness \leq 1.20$) options, and IV of ATM options ($\frac{IV_{OTMCall} - IV_{OTMPut}}{IV_{ATM}}$). In case of multiple option in the moneyness range volume weighted average is taken to estimate IV. Moneyness is defined as K/S, where K is strike price and S is stock price, and IV is estimated using Black (1976)	NSE Trade File

Table A2 : ATM-IV and Slope IV Curve around 52W high

Dependent variable:	ATM-IV		Slope of IV Curve	
	(1)	(2)	(3)	(4)
t-4	0.002		0.001	
	(0.004)		(0.005)	
t-3	0.002		0.008	
	(0.004)		(0.005)	
t-2	0.002		0.003	
	(0.004)		(0.005)	
t-1	−0.004		−0.00002	
	(0.004)		(0.005)	
t	0.006*		−0.019***	
	(0.003)		(0.005)	
t+1		−0.006**		0.021***
		(0.003)		(0.004)
t+2		−0.009***		0.033***
		(0.003)		(0.004)
t+3		−0.008***		0.034***
		(0.003)		(0.004)
t+4		−0.012***		0.029***
		(0.003)		(0.004)
t+5		−0.011***		0.032***
		(0.003)		(0.005)
Controls	Yes	Yes	Yes	Yes
Firm-level FE	Yes	Yes	Yes	Yes
Observations	5,522	6,431	4,816	5,754
Adjusted R^2	0.592	0.610	0.250	0.282

The table reports the 52W high panel data regression results of equation 12 (Column (1) & (3)) and 13 (Column (2) & (4)). Column (1-2) and (3-4) reports the results where volatility of at-the-money (ATM-IV) options, and slope of IV curve are dependent variables respectively. Each column of the table shows the coefficients of the model and standard errors in parenthesis. Controls include IVOL, SIZE, RET (20), P/C, ISKEW, BbyM, Leverage, Stock Price, SHRTURN, and Institution Percentage. *, **, and *** represent statistical significance at 10%, 5%, and 1% levels, respectively. The sample period spans from January 2011 to December 2019.

Table A3 : ATM-IV and Slope IV Curve around 52W low

Dependent variable:	ATM-IV		Slope of IV Curve	
	(1)	(2)	(3)	(4)
t-4	0.0003		−0.0001	
	(0.005)		(0.006)	
t-3	0.001		0.006	
	(0.005)		(0.006)	
t-2	0.001		0.004	
	(0.005)		(0.006)	
t-1	0.010*		0.006	
	(0.005)		(0.006)	
t	0.033***		−0.001	
	(0.005)		(0.006)	
t+1		−0.015***		−0.007
		(0.004)		(0.005)
t+2		−0.018***		−0.008
		(0.004)		(0.005)
t+3		−0.016***		−0.006
		(0.004)		(0.005)
t+4		−0.016***		−0.010*
		(0.004)		(0.005)
t+5		−0.017***		−0.003
		(0.005)		(0.005)
Controls	Yes	Yes	Yes	Yes
Firm-level FE	Yes	Yes	Yes	Yes
Observations	3,461	3,962	3,201	3,705
Adjusted R^2	0.634	0.685	0.226	0.288

The table reports the 52W low panel data regression results of equation 12 (Column (1) & (3)) and 13 (Column (2) & (4)). Column (1-2) and (3-4) reports the results where volatility of at-the-money (ATM-IV) options, and slope of IV curve are dependent variables respectively. Each column of the table shows the coefficients of the model and standard errors in parenthesis. Controls include IVOL, SIZE, RET (20), P/C, ISKEW, BbyM, Leverage, Stock Price, SHRTURN, and Institution Percentage. *, **, and *** represent statistical significance at 10%, 5%, and 1% levels, respectively. The sample period spans from January 2011 to December 2019.